An Introduction to the National Environmental METHODS Index

This updated, web-based tool compares available methods, and a related tool provides information for emergency situations.

LAWRENCE H. KEITH
INSTANT REFERENCE SOURCES, INC.
HERBERT J. BRASS
U.S. EPA
DANIEL J. SULLIVAN
U.S. GEOLOGICAL SURVEY
JAMES A. BOIANI
COMPUTER SCIENCES CORP.
KATHERINE T. ALBEN
WADSWORTH CENTER, NEW YORK STATE DEPARTMENT OF HEALTH

RHONDA SAUNDERS

Every year, U.S. federal and state government agencies, industrial entities, academic researchers, and private organizations expend enormous amounts of time and money for monitoring, protecting, and restoring water resources and watersheds. In 1999, industries spent \$599.5 million on monitoring and testing and \$3.154 billion on pollution abatement (*1*). Similarly, large expenditures are made to analyze for toxic wastes, biological organisms, contaminants in ambient air, and other pollutants for which measurement data can help with environmental decision making.

Selecting appropriate analytical methods is a critical part of planning for monitoring projects and can be a complex project in itself. Methods must have sufficiently low detection levels, suitable precision and analyte recovery, and acceptable selectivity for a specific monitoring project's needs.

Extended use of environmental analytical data (for new projects or uses) is usually not considered when methods are selected. Yet, analytical data are used again for other purposes, sometimes many years after publication. Whether extended use and interpretation of analytical data generated over time (and by various agencies) are valid depends on whether the applied methods produced data that are comparable. Data comparability exists when data are of known quality and can be validly examined for potential use, even in some cases when project objectives differ. Data comparability minimizes duplication and maximizes the use of resources. Perhaps more importantly, data generated for one purpose may be prevented from being used for other purposes when data comparability shows that a method provided data that are not compatible with the needs of the second purpose.

First launched in 2002, the National Environmental Methods Index (NEMI) is an online database of method summaries that includes basic information to compare one method with another for the purpose of method selection (*2*). A second version with advanced searching capability became available in 2004. The concept has been so well received that a database of methods to monitor chemical, biological, and radiological (CBR) contaminants that might be the basis of a terrorist attack on water supplies is also under development and will be available this summer (*3*). NEMI is currently funded by the U.S. Geological Survey (USGS) and the U.S. EPA with substantial support from the Methods and Data Comparability Board.

Historical perspective

In the past, comparing the quality and suitability of environmental methods was difficult because there was no master list of substances and methods for their measurement. EPA's Environmental Monitoring Methods Index (EMMI) grew out of a list of pesticides and other analytes routinely measured by the Industrial Technology Division (presently the Engineering and Analysis Division). Originally known as the "List of Lists", this list of analytes and methods became EMMI. Between 1990 and 1995, EMMI was expanded to encompass all lists of analytes published in the Code of Federal Regulations plus lists of additional analytes of interest to EPA. The 1995 revision included ~4200 substances and 3600 method abstracts with information on various media such as water, soil, air, and tissues and, when available, detection limits (*4*). EMMI could be searched by synonym, apparatus, CAS number, and other useful fields. When EMMI was developed, fields were created for future inclusion of method performance information. Independently, the first database of EPA method summaries linked to lists of analytes was published in 1990 in three volumes on diskettes (*5*). An MS Windows version of EPA pesticide method summaries followed in 1995 (*6*).

But even in 1995, no uniform standardized criteria existed in the world for comparing critical components of environmental analytical methods with each other or with a user's project-specific needs. Instead, published methods typically focused on specific analytical objectives and ignored information that would allow users to assess whether data from one particular method will be comparable with data produced by other methods and project designs.

To address this problem, a multiagency Methods and Data Comparability Board (MDCB) is working to provide recommendations that, if adopted, will make comparisons of methods and data more straightforward. The MDCB is a partnership of water-quality experts from federal and state agencies, tribes, municipalities, industry, and private organizations (*7*). The National Water Quality Monitoring Council created MDCB in 1997 to coordinate and provide guidance on implementation of nationwide monitoring strategies (*8*). Although the focus of the MDCB guidance was on water methods, the need for comparability applies equally well to environmental analytical methods in all media and various analytes (e.g., chemical, radiological, macrobiological, and microbiological).

Methods comparability

Table 1 presents the critical information that the MDCB recommends for all future environmental analytical methods to enable comparability of methods and data. Following these recommendations will facilitate comparisons of methods and data generated across agencies and project-specific monitoring programs. Methods containing these basic components can also be easily entered into NEMI.

Although the basic requirements for methods comparability are quite simple, many methods only meet some of them. Typically, newer methods contain more of the requirements than older ones, but even newer methods often lack several of the elements needed for comparability. Table 2 (see

TABLE 1

Basic requirements for comparability of environmental analytical methods

Costs must be considered and may vary among laboratories and companies. Costs of similar methods are compared with one another using broad cost ranges.

	Chemical methods	Biological methods
Method identifier information	Source, title, citation, date	Source, title, citation, date
Applicable to	Analytes and media/matrices	Organisms and media/matrices
Method summary	General procedural description with keywords	General procedural description, including species, age, type of system, type of measurement, test duration, and keywords
Major interferences	Other analytes and their potential sources	Contaminants, predators, food
Equipment	Major instrumentation and/or critical apparatus and techniques	Major instrumentation, techniques, and/or critical apparatus
Performance data	Detection level, bias and/or accuracy (e.g., percent recovery), precision, range, etc.	Accuracy (e.g., usually false positives and false negatives), precision, applicable range, etc.
Quality-control requirements	Reference standards	Reference organisms
Sample handling requirements	Container, preservation, storage, holding times, etc.	Sterilization, container, preservation, storage, holding times, etc.
Sample preparation	Filtering, dilution, homogenization, digestion, etc.	Filtering, media preparation, homogenization, warming-to-test temperature, oxygen, etc.

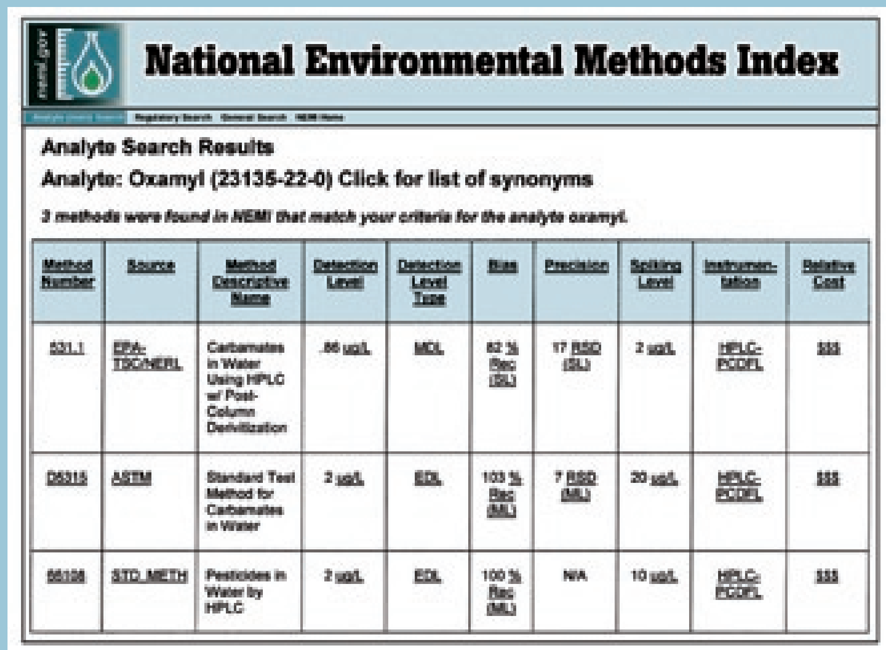
next page) provides typical examples of the relative percentages of methods that contain some of the more important performance-data categories listed in Table 1. In all cases, the methods were evaluated for analytes in water. Table 2 indicates that most methods have information on detection levels and other similar kinds of quality-control data that should be collected. Unfortunately, other useful performance data for methods comparability, such as percent recovery (or bias), precision, and applicable concentration range, are not included as frequently. However, newer methods tend to contain more of these important criteria, and this trend should be encouraged. Comparability is especially important as new technologies and sensors are developed, and their performance characteristics should be included in published methods.

NEMI's objective is to provide a user-friendly, searchable, online database of method summaries. Currently, the online index supports monitoring program planning for water programs, and the plan is to add more media. It is part of a larger effort to improve the comparability of water-quality data and environmental analytical data quality nationwide. Any group can submit a method for inclusion, but it must include criteria set by the MDCB (*7*), which ensures that data on critical aspects of methods will receive multiorganizational review and meet interagency needs.

FIGURE 1

Search for methods

Users who search NEMI for "oxamyl" methods will obtain a similar page. Underlined entries indicate links to more information.



Analyte Search Results

Analyte: Oxamyl (23135-22-0) Click for list of synonyms

3 methods were found in NEMI that match your criteria for the analyte oxamyl.

Method Number	Source	Method Descriptive Name	Detection Level	Detection Level Type	Bias	Precision	Spiking Level	Instrumentation	Relative Cost
531.1	EPA-TSC/NERL	Carbamates in Water Using HPLC w/ Post-Column Derivitization	.66 ug/L	MDL	82 % Rec (SL)	17 RSD (SL)	2 ug/L	HPLC-PCDFL	$$$
D5315	ASTM	Standard Test Method for Carbamates in Water	2 ug/L	EDL	103 % Rec (ML)	7 RSD (ML)	20 ug/L	HPLC-PCDFL	$$$
6610B	STD_METH	Pesticides in Water by HPLC	2 ug/L	EDL	100 % Rec (ML)	N/A	10 ug/L	HPLC-PCDFL	$$$

Searches and sources

NEMI requires only a modern browser and an Internet connection. Links are provided to the full methods in the public domain or, if they are copyrighted, to their commercial sources. Figure 1 illustrates an initial search for methods to detect the pesticide oxamyl. The most pertinent information for comparing the methods is listed. This includes the method identifier (typically a method number), source and descriptive name, detection level with reporting units and the type of detection level, bias (expressed either as percent recovery or as rates of false-positive and/or false-negative conclusions), precision (as relative standard deviation), spiking level used to generate precision data, major instrumentation, and relative cost of the method (expressed as one to four dollar signs).

Clicking on any of the underlined text links leads the user to additional information. For example, "method number 531.1" is linked to a brief summary of the method, including information about interferences, quality control, range, maximum holding times, and sample handling. The summary also contains a link to the full EPA method in a PDF format. Copyrighted methods, such as ASTM International and Standard Methods for the Examination of Water and Waste Water shown in Figure 1, are linked to their respective homepages.

NEMI contains more than 700 method summaries for organic, inorganic, nutrient, and radionuclide analytes, as well as microbiological organisms. Currently, most of the methods involve water analysis, but more methods for soil, sediments, and tissues can easily be added if funding becomes available. Future versions of NEMI may then include sampling and sample preparation methods and field analytical methods for water, soil, solid and liquid waste, air, and other matrices.

Table 2 shows that many of the methods, especially the older ones, lack information for some of the important fields. However, the absence of important information is, in itself, useful for methods comparison: Methods that have more information will be preferred, other criteria being equal.

NEMI currently lists methods developed by government agencies, including EPA, USGS, the National Oceanographic and Atmospheric Administration, and the U.S. Department of Energy, as well as private organizations such as ASTM International, Standard Methods for the Examination of Water and Wastewater, AOAC International, and several private companies. Authors can now use online forms on the homepage to submit methods for review that they think should be on the site. All methods submitted must be published in full and be available to the public.

TABLE 2

Typical percentages of selected performance data found in current NEMI methods

Analyte	Number of methods in NEMI	% of methods with detection levels	% with percent recovery[a]	% with precision (relative standard deviation)	% with applicable concentration range	% with quality-control information
Lead	28	100	50	68	54	86
Benzene	10	100	70	50	60	90
Radium-226	8	75	50	62	25	75
E. coli	13	100	69	38	92	100
Cryptosporidium	3	100	66	66	100	100

[a]Bias may be expressed as percent recovery of a spiked analyte or as rates of false-positive and false-negative conclusions under controlled and documented conditions.

In all cases, information is peer-reviewed for technical content and consistency with respect to measurement units, database business rules, and performance data before a method is entered into the database. Procedures for updating methods are also in place. When a new version of a method is published, the older version will be replaced in NEMI. The older method will be archived and still accessible, but it will not be searchable. Instead, it will be linked to the most recent method summary version. Archiving is especially important for regulatory purposes; older methods and data must be available for comparison, historical, or other purposes such as litigation involving data obtained using older methods.

A tool for water security

The CBR database on the NEMI site mirrors NEMI's format for finding and comparing methods (*3*). In addition, the CBR database includes fields listing how rapidly analytical results may be obtained and how specific a method is for the requested analyte or organism or for the class of analytes or organisms.

The CBR database also has a companion expert system, the CBR Advisor, which guides a user to the most useful methods for addressing a terrorism incident. This system can be used in several ways. In planning or training mode, this system can find methods for monitoring a suspected analyte or organism or confirming its identity. In response mode, it can find a method or methods that will provide information for making a decision as quickly as possible on the identity of a suspected analyte or organism in water. The expert system also provides advice on threat evaluation, operational responses, site characterization, initial site entry, and sampling based on EPA's Response Protocol Toolbox (*9*).

Reports document that the U.S. public health system is not prepared to detect a terrorist attack or quickly identify the substances used (*10*, *11*). In addition, laboratory personnel may not be ready for the special safety and analytical protocols necessary for working with these contaminants. The CBR Advisor quickly provides this kind of information, as well as advice about which methods to select or avoid, on the basis of the situation at hand. Both the NEMI-CBR and the CBR Advisor will be available to the public in the summer of 2005. Additional links will be available from EPA's website and the MDCB's website (*7*).

Methods and data comparability are important capabilities that have long been overlooked. As more environmental technologies and testing methods emerge, the economic and scientific aspects of methods and data comparability will increase in importance. Hopefully, NEMI will advance methods comparability and lead to more cost-effective environmental analytical data in the future.

Lawrence H. Keith is the president of Instant Reference Sources, Inc. Herbert J. Brass is a chemist and co-chair of the Methods and Data Comparability Board at the EPA Office of Groundwater and Drinking Water Technical Support Center. Daniel J. Sullivan is a hydrologist in the Wisconsin Water Science Center of USGS. James A. Boiani is a former environmental chemist at Computer Sciences Corp. Katherine T. Alben is a research scientist at the Wadsworth Center, New York State Department of Health. Address correspondence regarding this article to Keith at larrykeith@earthlink.net.

References

(1) U.S. Census Bureau. *Pollution Abatement and Costs Expenditures: 1999*; Nov 2002; www.census.gov/prod/2002pubs/ma200-99.pdf.
(2) National Environmental Methods Index, www.nemi.gov.
(3) NEMI-CBR, www.nemi.gov/cbr.
(4) *Environmental Monitoring Methods Index*; U.S. EPA: Washington, DC, 1995.
(5) Keith, L. H., Miller, W.; Smith, D. L. EPA's Sampling and Analysis Methods Database: Volume 1—Industrial Organics, Volume 2—Inorganics, and Volume 3—Pesticides (3 diskettes); Lewis Publishers: Boca Raton, FL, 1990.
(6) Keith, L. H. *Instant EPA's Pesticide Methods*; Instant Reference Sources, Inc.: Austin, TX, 1995; www.instantref.com.
(7) Methods and Data Comparability Board, http://wi.water.usgs.gov/methods.
(8) National Water Quality Monitoring Council, http://water.usgs.gov/wicp/acwi/monitoring/index.html.
(9) Magnuson, M.; et al. Responding to Water Contamination Threats. *Environ. Sci. Technol.* **2005**, *39*, 153A–159A.
(10) Trust for America's Health. *Public Health Laboratories: Unprepared and Overwhelmed*; Washington, DC, June 2003; http://healthyamericans.org/reports/files/LabReport.pdf.
(11) Connolly, C. Readiness for Chemical Attack Criticized. *The Washington Post*, June 4, 2003, p A11.